SOLUBILITY OF K IN METAL: PRELIMINARY RESULTS OF THE EFFECTS OF PRESSURE AND COMPOSITION. Nancy L. Chabot and Michael J. Drake, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721-0092.

The solubility of K in metal is of interest because of the possibility of radioactive heating as an energy source in planetary cores. The partitioning behavior between metal and silicate can be drastically affected by a number of thermodynamic variables, such as pressure, temperature, metallic and silicate compositions, and oxygen fugacity. We present preliminary experimental results which show K solubility is higher in the presence of S and doubles from 20 to 50 kbars. However, an experiment at 80 kbars with a different silicate melt composition shows no K solubility in sulfide metal. This is in striking contrast to the lower pressure runs and illustrates the complexity of the dependence of K solubility on the thermodynamic variables.

Introduction

The decay of K has long been considered an important heat source for all of the terrestrial planets. Often though, it is not considered a significant heat source for planetary cores. This is due to its tendency to form oxides and silicates and thus have a low solubility in metals. So, it follows that K would be concentrated in the silicate mantle and excluded from the metallic core during a core formation event.

However, the partition coefficients of elements are known theoretically and found experimentally to be dependent on a number of thermodynamic variables; pressure, temperature, oxygen fugacity, and silicate and metallic compositions can have a large influence over the resulting partitioning behavior. An increased solubility of K into a metallic core as a result of the specific conditions of core formation would have implications for the thermal history, geodynamo, and mantle dynamics of that planetary body. For example, current estimates of the heat source necessary in the Earth's core to maintain the observed magnetic field[1] predict 150 ppm K in the core would supply enough energy to drive convection and power the geomagnetic dynamo. It is thus of interest to understand the solubility of K as a function of the relevant thermodynamic variables because of the significant consequences radioactive heating as a planetary core energy source could have.

The role of radioactive heating in planetary cores is not a new question. Previous experimental studies have been conducted to examine the solubility of K into metal[2-7]. The majority of these results are at low pressures, and there are simply too few data to address the effect of many of the relevant thermodynamic variables. We have undertaken a project to extend the pressure range of the experimental data and to better understand all the parameters which might influence K solubility. Here we present preliminary results which examine the effects of pressure and composition.

Method

Because of concern over low K solubilities and detection limits, a K-rich silicate composition was desired for preliminary work. Ground K-feldspar was thus used as the starting silicate material. The metallic component of the experiments consisted of either Ni powder or Fe and FeS powder, and the metal and silicate powders were mixed together in approximately a 1:1 ratio. The mixtures were contained in graphite capsules, and all experiments were run at 1400°C in graphite furnaces.

Runs containing one charge of either Ni or Fe-FeS were conducted at 20 kbars in the piston cylinder and held at temperature for 24 hrs. Higher pressure experiments with Ni and Fe-FeS charges on either side of the thermocouple were run at 50 and 80 kbars in the multi-anvil for durations of two and one hours respectively.

Run products were analyzed by electron microprobe. Analysis of the silicate composition used a defocused beam of 5-10 mm and operating conditions of 12kV and 10nA with counting times of 10 sec., all to minimize loss of K and Na by vaporization. The metal was analyzed using three different methods: a highest magnification point analysis, a raster scan, and a defocused beam. For major elements in the metal, counting times were 20 sec. with probe operating conditions of 15kV and 20nA. However, to measure the low concentrations of K in the metal, the counting time was increased to 120 sec. and the beam current to 200nA. Analysis by the three different methods yielded similar results for the major elements and the K concentration in the metal.

Preliminary Results

With the caveats that we have demonstrated neither a close approach to equilibrium nor Henrian behavior in these exploratory experiments, we report the following results. Over the pressure range covered, 20 - 80 kbars, no K was detected in

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solid Ni metal in any of the run products. However, at just 20 kbars, 0.01 wt% K was measured in the liquid Fe-FeS, yielding a liquid metal/liquid silicate partition coefficient, D, of 10^{-3}. This partition coefficient is consistent with the value Murrell and Burnett[5] measured in a similar run at 15 kbars and $1450^{o}C$ with a basaltic silicate composition.

At 50 kbars, the amount of K measured in the liquid Fe-FeS is twice that of the 20 kbar run, yielding $D = 2 \times 10^{-3}$. In contrast, at 80 kbars with the same starting materials, detectable K was not observed in the liquid Fe-FeS. The most drastic change between the 80 kbars run product and the others is the silicate liquid composition. At 80 kbars, garnet and pyroxene crystallized and left the silicate liquid depleted in all elements except K and Si. This could have changed the role of K in the silicate liquid from network-former tonetwork-modifier, and could explain thedecreased solubility of K in the liquid Fe-FeS. Though a purely K and Si silicate liquid composition is not

of interest for planetary scenarios, it serves as a reminder that all thermodynamic variables should be considered when seeking to understand K solubility.

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